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Deepwater Horizon crude oil is cardiotoxic to the developing hearts of large pelagic fish

Proceedings of the National Academy of Sciences

J. P. Incardona, L. D. Gardner, **T. L. Linbo**, **T. L. Swarts**, A. Esbaugh, E. Mager, J. Stieglitz, **B. L. French**, **J. S. Labenia**, **C. A. Laetz**, M. Tagal, **C. A. Sloan**, A. Elizur, D. Benetti, M. Grosell, B. A. Block, and **N. L. Scholz (NMFS/NWFSC)**

- This paper describes the impacts of field-collected samples of Deepwater Horizon - MC252 crude oil on the rapidly developing embryos of warm-water predators, including bluefin and yellowfin tunas and an amberjack.
- For each species, environmentally relevant MC252 oil exposures caused serious defects in heart development. Moreover, abnormalities in cardiac function were highly consistent, indicating a broadly conserved developmental crude oil cardiotoxicity.
- Losses of early life stages were therefore likely for Gulf populations of tunas, amberjack, swordfish, billfish, and other large predators that spawned in oiled surface habitats.

The Deepwater Horizon disaster released more than 636 million L of crude oil into the northern Gulf of Mexico. The spill oiled upper surface water spawning habitats for many commercially and ecologically important pelagic fish species. Consequently, the developing spawn (embryos and larvae) of tunas, swordfish, and other large predators were potentially exposed to crude oil-derived polycyclic aromatic hydrocarbons (PAHs). Fish embryos are generally very sensitive to PAH-induced cardiotoxicity, and adverse changes in heart physiology and morphology can cause both acute and delayed mortality. Cardiac function is particularly important for fast-swimming pelagic predators with high aerobic demand. Offspring for these species develop rapidly at relatively high temperatures, and their vulnerability to crude oil toxicity is unknown. The authors assessed the impacts of field-collected Deepwater Horizon (MC252) oil samples on embryos of three pelagic fish: bluefin tuna, yellowfin tuna, and an amberjack. This study shows that environmentally realistic exposures (1 – 15 µg/L total PAH) cause specific dose-dependent





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defects in cardiac function in all three species, with circulatory disruption culminating in pericardial edema and other secondary malformations. Each species displayed an irregular atrial arrhythmia following oil exposure, indicating a highly conserved response to oil toxicity. A considerable portion of Gulf water samples collected during the spill had PAH concentrations exceeding toxicity thresholds observed here, indicating the potential for losses of pelagic fish larvae. Vulnerability assessments in other ocean habitats, including the Arctic, should focus on the developing heart of resident fish species as an exceptionally sensitive and consistent indicator of crude oil impacts.

Expected Publication Date: April 2014

Leatherback turtle movements, dive behavior, and habitat characteristics in ecoregions of the Northwest Atlantic Ocean

PLOS One

K. L. Dodge, B. Galuardi, **T. J. Miller (NMFS/NEFSC)**, and M. E. Lutcavage

- This paper documents the movement, dive behavior, and habitat characteristics of adult male, female, and subadult leatherback turtles (*Dermochelys coriacea*) tagged in a United States east coast foraging ground.
- The authors show that leatherback movements and environmental associations vary by oceanographic region, with area-restricted search behavior and shorter, shallower dives occurring in cool, productive, shallow shelf habitat with strong sea surface temperature fronts at temperate latitudes.

Leatherback sea turtles, *Dermochelys coriacea*, are highly migratory predators that feed exclusively on gelatinous zooplankton, thus playing a unique role in coastal and pelagic food webs. From 2007-2010, the authors used satellite telemetry to monitor the movements and dive behavior of nine adult and eleven subadult leatherbacks captured on the Northeast USA shelf and tracked throughout the Northwest Atlantic. Leatherback movements and environmental associations varied by oceanographic region, with slow, sinuous, area-restricted search behavior





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and shorter, shallower dives occurring in cool (median sea surface temperature: 18.4°C), productive (median chlorophyll *a*: 0.80 mg m^{-3}), shallow (median bathymetry: 57 m) shelf habitat with strong sea surface temperature gradients (median SST gradient: $0.23^{\circ}\text{C km}^{-1}$) at temperate latitudes. Leatherbacks were highly aggregated in temperate shelf and slope waters during summer, early fall, and late spring, and more widely dispersed in subtropical and tropical oceanic and neritic habitat during late fall, winter and early spring. We investigated the relationship of ecoregion, satellite-derived surface chlorophyll, satellite-derived sea surface temperature, SST gradient, chlorophyll gradient and bathymetry with leatherback search behavior using generalized linear mixed-effects models. The most well supported model showed that differences in leatherback search behavior were best explained by ecoregion and regional differences in bathymetry and SST. Within the Northwest Atlantic Shelves region, leatherbacks increased looping movements with increasing SST, but this relationship reversed within the Gulf Stream region. Leatherbacks increased looping movements with decreasing water depth in temperate and tropical shelf habitats. This relationship is consistent with increasing epipelagic gelatinous zooplankton biomass with decreasing water depth, and bathymetry may be a key feature in identifying leatherback foraging habitat in neritic regions. High-use habitat for leatherbacks in our study occurred in coastal waters of the North American eastern seaboard and eastern Caribbean, putting turtles at heightened risk from land- and ocean-based human activity.

Expected Publication Date: 19 March 2014

Linking recruitment synchrony to environmental variability

Fisheries Oceanography

M. Stachura, T. E. Essington, **N. J. Mantua (NMFS/SWFSC)**, **A. B. Hollowed (NMFS/AFSC)**, **M. A. Haltuch (NMFS/NWFSC)**, **P. D. Spencer (NMFS/AKFSC)**, T. A. Branch, and **M. J. Doyle (NMFS/AKFSC)**

- The authors found evidence in support of the hypothesis that species with shared





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sensitivity to environmental drivers have synchronous recruitment.

- There were consistent recruitment-environment relationships, especially in the Gulf of Alaska and California Current.
- Estimation of recruitment-environment relationships within relatively data-rich stocks sharing similar early life history traits may help inform these relationships for data-poor stocks sharing similar life history traits.

The authors investigated the hypothesis that synchronous recruitment is due to a shared susceptibility to environmental processes using stock-recruitment residuals for 52 marine fish stocks in three Northeast Pacific large marine ecosystems: the Eastern Bering Sea and Aleutian Islands, Gulf of Alaska, and California Current. There was moderate coherence in exceptionally strong and weak year classes, and correlations across stocks. With evidence of synchrony from these analyses, they used Bayesian hierarchical models to relate recruitment to environmental variables for groups of stocks that may be influenced by environmental processes as a result of their life histories. There were consistent relationships among stocks with variables, especially within the Gulf of Alaska and California Current. The best Gulf of Alaska model included Northeast Pacific sea surface height as a predictor of recruitment, and was particularly strong for stocks dependent on cross-shelf transport during their larval phase. In the California Current the best-fit model included San Francisco coastal sea level height as a predictor, where higher recruitment for many stocks corresponded to anomalously high sea level the year before spawning and low sea level the year of spawning. The best Eastern Bering Sea and Aleutian Islands model included several environmental variables, and there was some consistent response across stocks to these variables. Future research may be able to utilize these across-stock environmental influences, together with an understanding of appropriately scaled ecological processes important across early life history stages, to improve identification of environmental drivers of recruitment.

Accepted: 26 February 2014





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Unprecedented seasonal water level dynamics on one of the Earth's largest lakes

Bulletin of the American Meteorological Society

A. D. Gronewold and C. A. Stow (OAR/GLERL)

- Water level measurements on the Great Lakes have been collected for over 150 years, representing one of the longest sets of direct hydroclimate measurements on the planet.
- In the 2011 water year (October through September), water levels on Lake Erie rose 0.8 meters between February and June, the highest rise ever recorded for that four-month period.
- In the 2012 water year, water levels rose uncharacteristically between November and December and have since fallen for eight continuous months; water levels of any of the Great Lakes have never fallen continuously throughout the spring and early summer.
- Water levels on Lake Erie for 2012 reflect an historical but unexpected seasonal oscillation contrasting sharply with 2011 Lake Erie water levels, prompting closer examination of changes in the regional water budget due to shifts in climate.

The North American Great Lakes are among the largest unfrozen freshwater surfaces on earth. Seasonal and inter-annual fluctuations in Great Lakes water levels impact human, environmental, and economic well-being within the Great Lakes basin and across North America. Seasonal water levels on the Great Lakes have historically followed a persistent trend closely tied to the timing and magnitude of the major components of the regional water budget including precipitation, snow accumulation and ablation, and evaporation from the lake surfaces. Recent observations, however, indicate that water level and water budget dynamics are changing in dramatic and unexpected ways on at least one of the Great Lakes. In the 2011 water year (October through September), water levels on Lake Erie rose 0.8 meters between February and June, the highest rise ever recorded for that four-month period. Surprisingly, in the 2012 water year, water levels rose uncharacteristically between November and December and have since fallen for eight continuous months. Never before have water levels on any of the Great Lakes fallen continuously throughout the spring and early summer. The sharp contrast between the seasonal water level dynamics on Lake Erie in 2012 and those of both 2011 and the 150-





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year historical record have important implications for regional water budget and climate research, and for the possibility of similar changes in the near future on the other Great Lakes. Expected Publication Date: 3 March 2014

Real-time spatial management approaches to reduce bycatch and discards: experiences from Europe and the United States

Fish and Fisheries

A. Little, C. Needle, R. Hilborn, **D. S. Holland** (NMFS/NWFSC), and M. Tara

- Real time spatial management systems are an increasingly common way to manage bycatch.
- After initial review, the authors found that the most successful management approaches occur when they create incentives for fishermen to develop, use, and share the information and technology that enables them to avoid undesired catch.
- U.S. systems seem to be self-governed or co-managed and are more dynamic than European systems which tend to be more top down.

Spatial management measures are currently being used to manage bycatch and discards, capitalising on the spatial heterogeneity of fish distributions. Permanent or regular fishing closures which are often unresponsive to stock dynamics, poorly implemented and do not achieve their management objectives. Recently, real-time spatial management tools for managing bycatch and discards implemented under a co-management or self-governance approach are emerging in Europe and the US. Real-time catch and discard information is shared among fishers, and this information is combined with incentives to encourage vessels to leave areas of high bycatch. The similarities and differences, in governance, implementation and management of ten real-time spatial management case studies from across Europe and the US are reviewed. Here a framework is developed to characterise attributes associated with voluntary, private and regulatory real-time spatial management tools. Challenges and best practices of different case studies are reviewed providing insights for designing these spatial management tools. The results suggest approaches are most successful when they create





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incentives for fishermen to develop, use and share the information and technology that enables them to avoid undesired catch. Compared to Europe, the US has developed spatial management tools using more truly real-time mechanisms and with greater involvement of the fishing industry in designing and operating them.

Expected Publication Date: Spring 2014

Global patterns of seabird, marine mammal, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots

Proceedings of the National Academy of Sciences

R. L. Lewison, L. B. Crowder, B. Wallace, **J. Moore**, T. Cox, R. Zydelis, S. McDonald, A. DiMatteo, D. Dunn, C. Y. Kot, R. Bjorkland, S. Kelez, C. Soykan, **K. R. Stewart**, M. Sims, A. Boustany, A. J. Read, P. Halpin, W.J. Nichols, and C. Safina (NMFS/SWFSC)

- Measurement of global bycatch for air-breathing megafauna (seabirds, marine mammals, and sea turtles).
- Identifies taxa-specific hotspots of bycatch determining priority areas for conservation and research. Also finds evidence of cumulative impacts according to fishing fleets and gear type.

Recent research on ocean health has found large predator abundance to be a key element of ocean condition. Fisheries can impact large predator abundance directly through targeted capture and indirectly through incidental capture of non-target species, or bycatch. However, measures of the global nature of bycatch are lacking for air-breathing megafauna. We fill this knowledge gap and present the first global assessment of the distribution and intensity of bycatch of seabirds, marine mammals, and sea turtles based on empirical data from the three most commonly used types of fishing gears worldwide. We identify taxa-specific hotspots of bycatch intensity and find evidence of cumulative impacts across fishing fleets and gears. This global map of bycatch illustrates where data are particularly scarce - in coastal and small-scale fisheries and in ocean regions that support developed industrial fisheries and millions of small-scale fishers – and identify fishing areas where, given the evidence of cumulative hotspots





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across gear and taxa, traditional species or gear-specific bycatch management and mitigation efforts may be necessary, but not sufficient. Given the global distribution of bycatch and the mitigation success achieved by some fleets, the reduction of air-breathing megafauna bycatch is both an urgent and achievable conservation priority.

Accepted: 20 February 2014

ADDITIONAL ARTICLES

Assessing marine pelagic ecosystems: Regional and inter-annual trends in marine growth rates of juvenile salmon off the British Columbia coast

Marine Ecology Progress Series

B. Ferriss, M. Trudel, and B. R. Beckman (NMFS/NWFSC)

- Annual and seasonal differences were found in insulin-like growth factor 1 concentrations (a proxy for growth rate) in multiple species of salmon.
- These results demonstrate that salmon growth responds to local environmental variability on a scale of several hundred kilometers. IGF1 levels provide a mechanism linking local environmental conditions to variable salmon growth rates.
- Insulin-like growth factor 1 measures provide insight into fish performance on a relatively local regional and temporal scale and allow one to assess how habitats vary on this same scale.

In this study insulin-like growth factor 1 (IGF1) concentrations (a proxy for growth rate) were measured from juvenile coho (*Oncorhynchus kisutch*), sockeye (*O. nerka*), chum (*O. keta*), and Chinook salmon (*O. tshawytscha*) collected in eight regions of British Columbian coastal waters, in June of 2009, 2010, and 2011. The authors found annual differences in IGF1 for all four species of salmon, and species-specific regional differences in IGF1 concentrations in coho, chum and sockeye salmon. Sockeye and chum salmon had consistently higher values in the northern regions of the Dixon Entrance, Haida Gwaii, Hecate Strait, and lower values in Queen Charlotte Strait. Maximum differences in IGF1 levels ranged from 30.2 ng·ml⁻¹ (chum salmon, 2009, South Vancouver Island) to 74.2 ng·ml⁻¹ (coho salmon, 2011, Haida Gwaii).





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Regional differences in coho, chum and sockeye salmon were highly correlated ($R^2 = 0.61 - 0.75$).

Accepted: 14 January 2014

High levels of mesophotic reef fish endemism in the Northwestern Hawaiian Islands

Bulletin of Marine Science

C. Kane, **R. K. Kosaki**, and **D. Wagner** (NOS/ONMS)

- The authors conducted 52 mixed-gas dives and recorded a total of 179 reef fish species at mesophotic coral reef depths (30–90 m) across the NWHI.
- About 46% of encountered reef fishes in the NWHI are endemic to Hawaii, a value that is 16%–24% higher than previous shallow-water (<30 m) surveys in the NWHI, as well as nearly two-fold higher than in any other tropical region.
- This unprecedented rate of endemism indicates that mesophotic reefs in the NWHI are reservoirs of biodiversity, and further underscores the need for protection of this area.

The Papahānaumokuākea Marine National Monument surrounding the Northwestern Hawaiian Islands (NWHI) is the largest marine protected area in the United States and among the largest on Earth. The geographic isolation of this region has produced a unique biodiversity that is marked by particularly high levels of endemism. Previous surveys have revealed that on average 21% of reef fish species in the NWHI are endemic to the Hawaiian Archipelago. However, these endemism estimates are based on scuba surveys in shallow waters (<30 m). In areas with high water clarity like Hawaii, coral reefs can extend to depths exceeding 150 m. As noted previously for shallow reefs in the NWHI, endemism appears to increase with latitude, as relative abundances of endemic reef fishes on mesophotic reefs ranged from 16% at the southernmost end of the NWHI, to upwards of 92% at the northernmost end of the NWHI.

Published: 7 February 2014

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On the state of the knowledge of rainfall extremes in the Western and Northern Pacific Basin
International Journal of Climatology

M. C. Kruk (NESDIS/NCDC), A. Lorrey, G. Griffiths, M. Lander, E. Gibney (NWS), H. Diamond (NESDIS/NCDC), and J. Marra (NESDIS/NCDC)

- There is evidence of an increase in both the annual number of consecutive wet days and dry days in each of the major sub-regions of the Pacific Basin since the early 1940s, with higher increases in the annual trend in consecutive dry days.
- There are distinguishable changes in the frequencies of extreme rainfall events, mainly annually vs. seasonally.
- The trends in annual 1-day and 30-day extreme rainfall amounts showed a general mixed signal across the Pacific Basin that result from a set of trends that are not in total agreement, mainly along the continental coastlines.

The relevant literature on extreme rainfall events in the Pacific is relatively sparse compared to other regions (e.g., the coterminous United States, Europe, etc.). Moreover, several recent reports on climate in the Pacific mention the paucity of extremes information and often list “trends in historical climate” as a necessary next step. This study meets this need by examining historical trends and drivers of extreme rainfall events across the entire Pacific Basin, inclusive from Alaska southward to Australia, and longitudinally from the Philippines eastward to North America, with an emphasis on island and coastal locations (within 200 km of the coastline). There is evidence of a general decrease in the frequency of annual extreme rainfall events, yet the amount of extreme precipitation contributing to annual and seasonal totals appears to be on the rise. Region-wide, the number of consecutive dry days is increasing for those locations that are already dry, while the number of consecutive wet days is increasing for the already wet locales. The data for extreme rainfall statistics are considered to be relatively high quality for trend detection, while the level of understanding of the physical causes behind extreme rainfall is positively high. Since the ability to analyze the changes in historical rainfall extremes with some confidence is relatively recent, understanding is expected to improve in the future with the advancement of new datasets and “climate reanalysis” projects.

Expected Publication Date: Online publication by March 2014. In print by July 2014.





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Biblical influences on marine conservation: an examination of the apparent sustainability of kosher seafood

Ecology and Society

P. S. Levin (NMFS/NWFSC), J. Azose and S. Anderson

- For a sample of 4,500 seafood items from 68 supermarkets and 112 restaurants, authors found that food miles, energy consumption, and CO₂ emissions associated with transportation were all less for kosher than non-kosher seafood.
- The potential trophic impact of kosher seafood appears to be greater than non-kosher selections.
- Careful attention to the environmental costs and benefits of traditional foodways (*i.e.*, kosher) is an important entry point for engagement with cultural practices and belief systems.

In response to widespread concern about the state of marine ecosystems and the perceived failure of existing policies, many organizations are developing market-based instruments that promote sustainability. Eco-standards such as shopping guides, eco-labels and stewardship certifications are now commonplace. However, in many cultures dietary guidelines have existed for thousands of years, and anthropologists have argued that such dietary rules emerged to reduce environmental impacts by encouraging exploitation of productive species, increasing ecological efficiency, or decreasing harvest of apex predators. This study explored some of the environmental consequences for marine and aquatic systems of one of the more familiar ancient dietary traditions—keeping kosher. The authors sampled nearly 4,500 seafood items from 68 supermarkets and 112 restaurants. For each species it was determined whether the item was kosher or not and then estimated trophic level, food miles, energy consumption and carbon dioxide emissions. Results revealed that food miles, energy consumption, and CO₂ emissions associated with transportation were all less for kosher than non-kosher seafood. In general, these differences could be mitigated by consuming only Monterey Bay Aquarium Seafood Watch “best” choices. On the other hand, while food miles, energy consumption and carbon dioxide emissions associated with kosher seafood appears to be lower than non-kosher seafood, the potential trophic impact





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of kosher seafood appears to be greater than non-kosher selections. These results highlight that even though the moral underpinnings of conservation and religion can be very different, careful scientific attention to the environmental costs and benefits of traditional foodways offers an important entry point for engagement with cultural practices and belief systems.

Expected Publication Date: Spring 2014

Rapid parallel evolution of standing variation in a single, complex, genomic region is associated with life history in steelhead/rainbow trout

Proceedings of the Royal Society B: Biological Sciences

D. Pearse, M. Miller, A. Abadía-Cardoso and J. C. Garza (NMFS/SWFSC)

- Using genetic techniques the authors describe the population-level correlation of the most common life history strategy in steelhead (anadromous) and rainbow trout (resident).
- The authors provide the first evidence of a common genomic basis for life-history variation in steelhead and rainbow trout.
- These findings extend our knowledge of the heritable basis of rapid adaptation of complex traits in novel habitats.

Rapid adaptation to novel environments may drive changes in genomic regions through natural selection. Such changes may be population-specific or, alternatively, may involve parallel evolution of the same genomic region in multiple populations, if that region contains genes or co-adapted gene complexes affecting the selected trait(s). Both quantitative and population genetic approaches have identified associations between specific genomic regions and the anadromous (steelhead) and resident (rainbow trout) life-history strategies of steelhead and rainbow trout (*Oncorhynchus mykiss*). Here authors use genotype data from 95 single nucleotide polymorphisms and show that the distribution of variation in a large region of one chromosome, Omy5, is strongly associated with life-history differentiation in multiple above-barrier populations of rainbow trout and their anadromous steelhead ancestors. The associated loci are in strong linkage disequilibrium, suggesting the presence of a chromosomal inversion or other rearrangement limiting recombination. These results provide the first evidence of a common genomic basis for life-history variation in *O. mykiss* in a geographically diverse set of





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populations, and extends our knowledge of the heritable basis of rapid adaptation of complex traits in novel habitats

Expected Publication Date: TBD

Intermittent breeding and constraints on litter size: consequences for effective population size per generation (N_e) and per reproductive cycle (N_b)

Evolution

R. S. Waples (NMFS/NWFSC) and T. Antao

- Authors consider how effective population size is affected by two common life history traits: intermittent breeding (e.g., females skip one or more reproductive cycles after giving birth as in cetaceans or sea turtles) and small litter size (e.g., females only give birth to one offspring per reproductive cycle).
- Simulated data for six model species showed that both intermittent breeding and litter-size constraints increase the effective population size per generation, but only slightly. The authors show how to quantitatively account for these effects.
- These results will improve our ability to predict evolutionary processes in natural populations.

In iteroparous species, it is easier to estimate N_b , or the effective number of breeders in one reproductive cycle than N_e , or effective population size per generation. N_b can be used as a proxy for N_e and also can provide crucial insights into eco-evolutionary processes that occur during reproduction. The authors used analytical and numerical methods to evaluate effects of intermittent breeding and litter/clutch size on inbreeding N_b and N_e . Fixed or random litter sizes of 3 or larger have little effect on either effective-size parameter; however, in species (e.g., many large mammals) in which females can produce only one offspring per cycle, female $N_b = \text{infinity}$ and overall $N_b = 4N_b$ (male). Intermittent breeding reduces the pool of female breeders, which reduces both female and overall N_b ; reductions are larger in high-fecundity species with high juvenile mortality and increase when multiple reproductive cycles are skipped. Simulated data for six model species showed that both intermittent breeding and litter-size constraints increase N_e , but only slightly. The authors show how to quantitatively account for these effects,





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which are important to consider when a) using N_b to estimate N_e , or b) drawing inferences about male reproductive success based on estimates of female N_b .

Published online: <http://onlinelibrary.wiley.com/doi/10.1111/evo.12384/pdf>

Opportunistic acoustic telemetry platforms: lessons from the Gulf of Maine Fisheries

G. S. Goulette, J. P. Hawke, J. F. Kocik, J. P. Manning (NMFS/NEFSC), P. A. Music, J. P. Wallinga and G. Barbin Zydlewski

- Utilizing existing aquatic (marine, river, lake) infrastructure as platforms for research allow for significant expansion of the research footprints and information gains at minimal cost.
- Collaboration and partnerships are developed through investigating and implementing deployment opportunities with oceanographers and commercial fishers

Biologists are able to monitor animal behavior, habitat use, and survival through local telemetry technologies. Migratory species cross these lines among study projects, thus connecting projects. Biologists can further these connections by expanding the area monitored, but this step is expensive. The authors evaluated three opportunistic platforms: 1) oceanographic buoys, 2) commercial fishing gear, and 3) drifters to test the feasibility of expanding coverage while minimizing costs. All Gulf of Maine platforms provided novel data, generating over 15,000 detections from animals released by 18 organizations. Performance was strong for buoys and commercial gear but low recovery hampered drifter utility; although, advances in real-time drifter communication should improve future efficacy. Opportunistic platforms proved to be a low-cost method that can benefit researchers across aquatic systems. Animals from other studies connected us with researchers fostering dialog and highlighted information gains from data sharing. Working with fishers and oceanographers also strengthens interdisciplinary and stakeholder communication and can increase overall public understanding and support

Expected Publication Date: Summer 2014

A Bayesian network incorporating observation error to predict phosphorus and chlorophyll a in





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Saginaw Bay

Environmental Modeling and Software

Y. K. Cha and C. A. Stow (OAR/GLERL)

- Based on field measurements from Lake Huron, the authors developed a model of phosphorus and chlorophyll *a* relationships that accounts for the observation error inherent in field observations.
- This model predicts lake conditions more accurately than models that do not incorporate observation error, providing a basis for evaluation of management targets.
- Models will help guide decision-making related to the 2012 Great Lakes Water Quality Agreement.

Empirical relationships between lake chlorophyll *a* and total phosphorus concentrations are widely used to develop predictive models, using sample averages that may not accurately reflect lake-wide averages. This can result in inaccurate estimates and greater uncertainty in model outcomes. The authors develop a Bayesian network model based on empirical chlorophyll-phosphorus relationships for Saginaw Bay, an embayment on Lake Huron. The model treats the means as unknown parameters, and includes structure to accommodate the observation error associated with estimating those means. Compared with results from an analogous simple model using sample averages, the observation error model has a lower predictive uncertainty and predicts lower chlorophyll and phosphorus concentrations under contemporary lake conditions. These models will be useful to guide pending decision-making pursuant to the 2012 Great Lakes Water Quality Agreement.

Published Online: <http://www.sciencedirect.com/science/article/pii/S1364815214000619>

Manifestations of M-I coupling across the auroral oval and polar cap during storm-substorm activity driven by interplanetary CMEs: ground-satellite conjunction studies

Annales Geophysicae

P. E. Sandholt, C. Farrugia and W. F. Denig (NESDIS/NGDC)

- Safe and effective satellite operations support the NOAA initiative for a Weather Ready Nation. An improved understanding of the space environmental conditions that are





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disruptive to satellite operations can be used to develop strategies that can help mitigate the impacts of space weather.

- The authors provide a morphological description of phenomena relevant to geomagnetic substorm activation signatures in the high-latitude nightside auroral zone. Geomagnetic substorms can adversely impact geostationary satellite operations and result in spacecraft anomalies similar to that which affected telecommunications satellite Galaxy-15.

The authors examined repetitive events of magnetosphere - ionosphere (M-I) coupling during long intervals of continuously strong solar wind forcing, during which the Harang reversal (HR) boundary expands into the 1700 -1800 MLT sector. Using data acquired across the auroral oval at dusk in ground - satellite conjunctions, the authors document structure and evolution of M-I coupling from the plasma sheet (PS) - partial ring current (PRC) system via R1 and R2 field-aligned currents (FACs) during auroral electrojet activations appearing on the poleward and equatorward sides of the Harang reversal boundary (HR-north and HR-south), respectively. The advantage of their scientific approach lies in the combination of (i) continuous ground observations of the evolution of M-I coupling signatures within a wide latitude range across the auroral oval (IMAGE chain magnetograms), and (ii) “snapshot” satellite (DMSP F13) observations of FAC/precipitation/ion drift profiles in HR-S and HR-N in different phases of the substorm-storm activity (AL - SYM-H index events), in relation to (iii) the evolution of substorm current systems (Bostrøm types I and II) as inferred from magnetic field observations at geostationary altitude. HR-N is characterized by ionospheric Pedersen current closure of R1 FACs, equatorward – moving auroral streamers (inverted-V arcs) and streamer channels. HR-S is characterized by R2 FAC closure leading to eastward electrojet (EEJ) activity and a broad energy band of diffuse electron precipitation in the southern auroral branch. The approach allows them to document the evolution of polar cap convection, as derived from the PCN - index, in relation to 3 direct satellite observations of the substorm current systems from DMSP F13 and GOES - 10. The authors distinguish between two substorm activity levels: (i) Major SCW - electrojet expansions with AL-excursions reaching -1000 to -1600 nT, followed by SYM-H dips (plasma injections to the PRC). This evolution is associated with excitation of bipolar FAC sheets in the flow braking regime (injection dynamo) in the inner PS, giving rise to EEJ-





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enhancements in HR-S. (ii) A phase of partial AL-recovery characterized by shorter AL dips reaching values within -600 to -1000 nT, relating to a series of M-I coupling events (bursty bulk flows and activation of PS current wedgelets) with manifestations on both sides of the HR boundary, most notably auroral streamer events in HR-N and EEJ events/auroral brightenings in HR-S, leading to equatorward/poleward motions of the HR boundary. The major plasma injection events (i) are observed to be followed by a partial recovery of the ring current index and a weakening of the R2 FAC coupling. The SYM-H partial recovery is attributed to an overshielding of the Volland–Stern E-field due to M-I coupling at subauroral latitudes.

Expected Publication Date: May 2014

Effects of hydraulic dredging on the benthic ecology and sediment chemistry on a cultivated bed of the hard clam, Mercenaria mercenaria

Aquaculture

R. Goldberg , J. M. Rose, R. Mercaldo-Allen, S. L. Meseck, P. Clark, C. Kuropat, and J. J. Pereira (NMFS/NEFSC)

- This study demonstrates that hydraulic clam dredging did not cause measurable disturbance to the benthic community or sediment chemistry of a Long Island sound clam bed.
- Settlement of hard clams was greater on plots that were hydraulically dredged as compared to adjacent not dredged plots.
- These experimental data suggest that a clam dredging event on a leased, cultivated bed had limited effects and may have enhanced hard clam recruitment.

The authors examined effects of hydraulic dredging on the benthic ecology and sediment biogeochemistry of a leased, shellfish bed in Long Island Sound near Milford, Connecticut, where hard clam, *Mercenaria mercenaria* (Linnaeus 1758), aquaculture is conducted. Six 1 ha plots were sampled at 1-2 week intervals from June through October of 2010. One-time hydraulic dredging was conducted to harvest hard clams on 3 dredged treatment plots in mid June, while 3 control plots remained not dredged. Repeated measures analysis indicated no significant differences between dredged and not dredged plots for any of the ecological indices or sediment chemistry measurements. Numbers of newly settled hard clams were significantly





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higher on dredged plots. Cluster analysis indicated a strong seasonal influence on benthic community structure distinguishing between early and late season assemblages. Hydraulic shellfish harvesting as conducted on leased beds in Long Island Sound did not appear to significantly impact benthic assemblages or sediment biogeochemistry, while sediment grain size and sampling date had a greater influence on benthic community structure.

Expected Publication Date: Spring 2014

Genetic identification of Chinook salmon in the Columbia River estuary: stock-specific distributions of juveniles in shallow freshwater habitats

North American Journal of Fisheries Management

D. J. Teel, D. L. Bottom, S. A. Hinton, D. R. Kuligowski, G. T. McCabe, Jr., R. A. McNatt, G C. Roegner, L. A. Stamatiou, C. A. Simenstad (NMFS/NWFSC)

- Data from this study provide improved descriptions of the near-shore estuary habitat use of several Columbia River genetic stocks of Chinook salmon that can assist managers in the design and selection of estuary restoration projects.

Extensive efforts are underway to restore and conserve near-shore shallow water habitats in the Columbia River estuary with the intent of increasing the estuary's capacity to provide food, refuge, and other crucial ecosystem functions for juvenile salmon. Juvenile Chinook salmon, including those from the five Evolutionarily Significant Units listed as threatened or endangered under the U.S. Endangered Species Act, are particularly expected to benefit from the habitat improvements. However, information on the temporal and spatial estuarine distributions of juveniles from specific populations or stocks is lacking and impedes restoration planning for at-risk salmon. We conducted a series of surveys to sample juvenile Chinook salmon occupying shallow sandy beach habitats in six hydrogeomorphic reaches across the tidal freshwater portion of the estuary and also at one long-term reference site near the estuary mouth. Sites were sampled bi-monthly over 26 months during 2010-2012 to capture seasonal patterns of stock-specific habitat use. Genetic stock identification analyses were conducted on the samples using microsatellite DNA loci and genotypic data representing spawning populations from throughout the Columbia River Basin. We identified three tidal freshwater areas that could be distinguished





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by genetic stock composition. Lower tidal freshwater reaches were dominated by fall run juveniles from West Cascade tributaries (>70%), upper reaches had a large proportion of fish from the Upper Columbia River summer/fall stock (>60%), and middle reaches were characterized by greater stock diversity with no single stock contributing more than 30% in each reach. Stock-specific juvenile habitat use differed by season, life history type, and between natural and hatchery produced fish. Data from this study provide improved descriptions of the near-shore estuary habitat use of several Columbia River genetic stocks of Chinook salmon that can assist managers in the design and selection of estuary restoration projects.

Expected Publication Date: Spring 2014

Evaluating the impact of individual fishing quotas (IFQs) on the technical efficiency and composition of the US Gulf of Mexico red snapper commercial fishing fleet

Food Policy

D. Solis, J. del Corral, **L. Perruso (SEFSC)**, **J. Agar (SEFSC)**

- Authors demonstrate the effects of IFQ management in the red snapper commercial fishery
- Authors discuss the improvement of technical efficiency in the Gulf of Mexico red snapper fishing fleet with the use of IFQs
- The results of this work were used in a five year IFQ review

The increased use of individual fishing quotas (IFQs) is reshaping fisheries management around the world. This study examines the impact of IFQs on the technical efficiency (TE) and composition of the Gulf of Mexico red snapper commercial fishing fleet. Employing a parametric stochastic distance frontier framework we find that IFQs improved the TE of the vertical line and bottom longline fleets. Our results suggest that the observed TE gains were mainly driven by the retirement of less efficient vessels and, to a lesser extent, by efficiency gains of the remaining vessels. We also document changes in output and input distance elasticities and in returns to scale following the introduction of IFQs. The paper also investigates the impact of regulations and weather on productivity and the effect of crowding on TE. Policy implications stemming from these results are also discussed.

Expected Publication Date: August 2014





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Impact of stirring on the luminescent optical dissolved oxygen optode

North American Journal of Aquaculture

J. E. Colt (NMFS/NWFSC)

- The author investigated the impact of stirring on the response of the YSI ProODO luminescence dissolved oxygen sensor or optode.
- The results indicate that stirring is required to optimize measurement accuracy for the LDO dissolved oxygen sensor

The author measured dissolved oxygen using a YSI ProODO luminescence dissolved oxygen sensor or optode in a 250 mL BOD both with and without use of a magnetic stirrer. Using a water sample from a simulated fish transport experiment, the author found that measured dissolved oxygen dropped by 2-3 mg L⁻¹ when the magnetic stirrer was turned off for 11 minutes. The measured dissolved oxygen returned to a value projected from the oxygen uptake rate after the stirrer was turned on. The author observed a much smaller impact 18.2 M high purity water (mean: -0.11 mg L⁻¹). Acid washing the BOD bottle/stir bar and cleaning the optode cap reduced the decrease to -0.08 mg L⁻¹. Based on t-tests between pairs of samples measured with and without stirring, lack of stirring had a significant impact on measured dissolved oxygen. The source of this effect and its potential impact on the accuracy of the optical probe under typical operating conditions remains to be determined.

Expected Publication Date: 15 March 2014

*Evaluation of a single nucleotide polymorphism baseline for genetic stock identification of Chinook salmon (*Oncorhynchus tshawytscha*) in the California Current Large Marine Ecosystem*

Fishery Bulletin

A. Clemento, E. Crandall, J. C. Garza, and E. Anderson (NMFS/SWFSC)

- This manuscript describes the development and validation of the first genetic stock identification (GSI) baseline database specifically designed for use in fisheries managed by the Pacific Fishery Management Council.





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- This novel genetic stock identification baseline is composed of genotypes from over 8,000 individual fish from 69 distinct populations at 96 single nucleotide polymorphism (SNP) loci and represents likely sources for over 99 percent of the fish encountered in ocean salmon fisheries off California and Oregon.

Chinook salmon from the West Coast of North America are an economically and ecologically important species and a major component of North Pacific Ocean fisheries. Their anadromous life history strategy generates populations (or stocks) that are frequently genetically differentiated from one another, although not visually discernable. In many cases, it is desirable to discern the stock of origin of an individual fish or the stock composition of a mixed sample to monitor stock-specific impacts and alter management accordingly. Genetic stock identification (GSI) provides such discrimination and we describe here a novel GSI baseline composed of genotypes from over 8,000 individual fish from 69 distinct populations at 96 single nucleotide polymorphism (SNP) loci. The populations included in the baseline represent the likely sources for over 99 percent of the fish encountered in ocean salmon fisheries off California and Oregon. This new genetic baseline permits GSI using rapid and cost effective SNP genotyping, and power analyses indicate that it has near maximum power for discriminating most Chinook salmon stocks to the level of resolution needed for fishery management by the Pacific Fishery Management Council. In an ocean fishery sample, GSI assignments of over 1000 fish, using our baseline, were highly concordant (99%) at the reporting unit level to identifications from the physical coded wire tags recovered from the same fish. This SNP baseline represents an important advance in the technologies available for fishery management and ecological investigation of Chinook salmon at the southern end of their geographic range.

Expected Publication Date: April 2014

Effects of ghost fishing on the population of red king crab (Paralithodes camtschaticus) in Womens Bay, Kodiak Island, Alaska

Fishery Bulletin

W. C. Long, P. A. Cummiskey, and J. E. Munk (NMFS/AKFSC)





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- The authors tagged and tracked 192 red king crabs with carapace lengths (CLs) from 42 to 162 mm in Womens Bay, Kodiak Island, Alaska from 1991 to 2008 to quantify the effects of ghost fishing on the population.
- The results indicate that ghost fishing is a major source of mortality for red king crab in Women's Bay, resulting in mortality of between 16 and 37 percent of crabs with carapace lengths greater than 60 mm during the study period.

Ghost fishing, the capture and killing of marine organisms by lost or abandoned fishing gear, is a serious ecological and economic problem confronting fisheries. In this study, the authors quantify the effect of ghost fishing on the population of the red king crab (*Paralithodes camtschaticus*) in Womens Bay, Kodiak Island, Alaska. From 1991 to 2008, crabs with carapace lengths (CLs) from 42 to 162 mm were tagged with acoustic tags and tracked both from the surface and by divers. Diver observations were used to determine whether a crab molted or died and, in many cases, the cause of death. Of 192 crabs tracked during this study in association with other projects, 13 were killed in ghost fishing gear (12 in ghost crab pots and 1 in a ghost gill net) and 20 were captured in ghost pots and released by divers. An additional 13 died of other causes, including predation by sea otters and an octopus and by human poaching. We estimate that between 16% and 37% of the population of red king crabs with CLs >60 mm in Womens Bay were killed by ghost fishing per year during the period of this study, making ghost fishing a substantial source of mortality. These results indicate that steps to reduce ghost fishing in Womens Bay are warranted.

Accepted: 6 February 2014

Leaf litter water content to soil surface CO₂ fluxes in a deciduous forest

Agricultural and Forest Meteorology

T. B. Wilson, J. Kochendorfer, T. P. Meyers, M. Heuer, K. Sloop, and J. Miller (OAR/ARL)

- This study evaluated litter water content and soil-litter CO₂ fluxes in a deciduous forest site in Oak Ridge, TN using commercially-available, low-power, low-cost miniature soil moisture probes.





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- Measurements of the litter water content displayed large spatial variability and the results indicate that about 25% percent of the forest floor CO₂ flux was due to direct contributions from the litter layer
- The probes performed well in a complex forest environment characterized by large spatial variability and small magnitude of energy, water and carbon fluxes, indicating that they can be used to help evaluate the water, energy and CO₂ fluxes on the soil surface inside a variety of vegetation stands.

This study examined the ability of a commercial, miniature soil moisture probe to measure water content within the leaf litter layer of a deciduous forest in Oak Ridge, eastern Tennessee. The authors compared miniature probe measurements of litter moisture to gravimetric measurements from litter sample baskets positioned across the forest floor and found that the change in the magnitude of the probe output correlated linearly to the water content of the litter. Gravimetric measurements of the litter water content ranged from 1 to 3 g (H₂O) g⁻¹ (litter dry weight), and hourly values varied with precipitation, radiation, and wind speed. Measurements of the litter and soil water content were incorporated into empirical models adopted from the literature to estimate the litter and soil components of the CO₂ flux. The comparison between the modeled and the measured hourly CO₂ flux on the forest floor produced root means square differences (RMSD) of about 1.11 and 1.32 mmol m⁻² s⁻¹ for estimates with and without litter layer, respectively. About 25% percent of the forest floor CO₂ flux was due to direct contributions from the litter layer. The results of the study indicate that the probes performed well in a complex forest environment and can be used to help evaluate the water, energy and CO₂ fluxes on the soil surface inside a variety of vegetation stands.

Expected Publication Date: 1 April 2014

Juvenile salmon in estuaries: comparisons between North American Atlantic and Pacific salmon populations

Reviews in Fish Biology and Fisheries

L. Weitkamp (NMFS/NWFSC), G. Goulette , J. Hawkes, M. O'Malley, and C. Lipsky (NMFS/NEFSC)

- Researchers from both Pacific and Atlantic salmon realms utilize similar methods and tools to monitor salmon populations and can benefit from each other's work.





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- Estuaries play an important role in the life histories of both Pacific and Atlantic salmon populations, but there is a need to develop a better understanding of interactions between salmon and other estuarine fishes.
- The authors identify actions that could hasten restoration of both Atlantic and Pacific salmon populations.

All anadromous fishes, including juvenile salmon, encounter estuarine habitats as they transition from riverine to marine environments. The authors compared the estuarine use between juvenile Atlantic salmon (*Salmo salar*) in the Penobscot River estuary and Pacific salmon (*Oncorhynchus* spp.) in the Columbia River estuary. Both estuaries have been degraded by anthropogenic activities. Atlantic and Pacific salmon populations in both basins rely heavily on hatchery inputs for persistence. Pacific salmon, as a group, represent a continuum of estuarine use, from species that move through rapidly to those that make extensive use of estuarine habitats. While Atlantic salmon estuarine use is most similar to that of rapidly moving Pacific salmon, they can exhibit nearly the entire range of Pacific salmon estuarine use. Both slow and rapidly migrating Atlantic and Pacific salmon actively feed in estuarine environments, consuming insect and invertebrate prey. Interactions between juvenile salmon and estuarine fish communities are poorly understood in both estuaries, although they experience similar avian and marine mammal predators. Estuaries are clearly important for Atlantic and Pacific salmon, yet our understanding of this use is currently insufficient to make informed judgments about habitat quality or overall estuary health.

Expected Publication Date: Summer 2014 (online sooner)

Cross-scale interactions: a conceptual framework for understanding multi-scaled cause-effect relationships in macrosystems

Frontiers in Ecology and the Environment

P. A. Soranno, K. S. Cheruvilil, E. G. Bissell, M. T. Bremigan, J. A. Downing, C. E. Fergus, C. T. Filstrup, E. N. Henry, N. R. Lottig, E. H. Stanley, **C. A. Stow (OAR/GLERL)**, P.-N. Tan, T. Wagner, and K. E. Webster

- The authors offer an approach for measuring cross-scale interactions using 2100 lakes in 35 regions in North America





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- Ultimately, this approach can serve as a basis for efforts to understand a wide variety of multi-scaled problems such as climate change, land-use/land-cover change, and invasive species.

Ecologists are increasingly discovering that ecological processes are made up of components that are multiscaled in space and time. Some of the most complex of these processes are cross-scale interactions (CSIs), which occur when components interact across scales. When undetected, such interactions may cause errors in applying those components from one region to another. CSIs, particularly those that include a regional scaled component, have not been systematically investigated or even reported because of the challenges of acquiring data at sufficiently broad spatial extents. The authors present an approach for quantifying CSIs and apply it to a case study investigating one such interaction, between local and regional scaled land-use drivers of lake phosphorus.

Expected Publication Date: 28 February 2014

*Notes on the reproductive biology of female salmon sharks, *Lamna ditropis*, in the eastern North Pacific Ocean*

Transactions of the American Fisheries Society

C. L. Conrath, C. A. Tribuzio (NMFS/AKFSC), and K. J. Goldman

- This study presents data on the reproductive biology of the salmon shark necessary for improving stock assessment and management of this species
- Salmon sharks were found to have a biennial reproductive cycle, with a 9 month gestation time, a resting year between pregnancies, and produced around four sharks per litter.

Little is known about the reproductive biology of the salmon shark, *Lamna ditropis*, from the eastern North Pacific Ocean. Female salmon shark specimens were collected from Alaskan waters in the summer, autumn, and winter to examine reproductive seasonality and output, the reproductive interval, and embryonic development. Female salmon sharks were found to ovulate during the autumn months of September and October, and those captured in July were either in a resting or postpartum state, indicating a short gestation time. The presence of two mature reproductive states in both the summer and autumn months indicates a biennial reproductive cycle and a resting period of at least 14 months between parturition and ovulation.

Published Online: 3 March 2014





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Environmental awareness and public support for protecting and restoring Puget Sound Journal of Environmental Management

K. C. Norman, M. Henly, K. E. Mills, and **P. S. Levin (NMFS/NWFSC)**

- These findings demonstrate that environmental awareness influences public support for policy tools.
- The nature of particular management actions and social forces can have important mitigating effects that need to be considered by practitioners attempting to promote integrated approaches to environmental management.

In order to garner public support, environmental professionals have attempted to increase awareness about environmental threats and illustrate the need for action. Nonetheless, how beliefs about the scope and severity of different types of environment problems are interrelated or whether environmental awareness shapes support for management interventions is less clear. Using data from a telephone survey of residents of the Puget Sound region, the authors investigated how perceptions of different environmental issues, along with other social factors, affect attitudes about policy options. Our results show that self-assessed environmental understanding and views about the seriousness of pollution, habitat loss, and salmon declines are only weakly related. Further analysis shows that women and individuals that believe pollution threatens Puget Sound are more likely to support a range of environmental policy tools. Conversely, self-identified Republicans and individuals who view current regulations as ineffective tend to oppose governmental actions designed to protect and restore Puget Sound. One policy measure displays distinct patterns – tax credits for environment-friendly business practices. In this case, political party affiliation does not have significant effects, and a belief that wildlife habitat is being lost across Puget Sound leads to less support for tax credits. Expected Publication Date: Summer 2014

Reflectivity vortex hole in a tornadic supercell

Journal of Operational Meteorology

C. J. Schultz (NWS, Billings, MT)

- Reflectivity vortex holes likely grow upward with time in most cases and may precede tornadoes by several minutes.





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- A vortex hole observed at close range in 2011 shows that, although they do not provide direct evidence of a tornado, reflectivity vortex holes can supplement polarimetric debris signatures to aide meteorologists in detecting tornadoes and specifying their location. The Weather Surveillance Radar-1988 (WSR-88D) at Thedford, Nebraska, detected a distinct reflectivity minimum in the hook echo of a tornadic supercell over north central Nebraska on 11 August 2011. This “eye-like” feature was co-located with a tornadic vortex signature and was detectable to an altitude exceeding 8 km above ground level. A literature review of “eye-like” features in radar imagery in association with tornadic storms revealed that these signatures have been documented since the 1950s, but may have only recently become more commonly observed by WSR-88Ds with the change to super-resolution grid spacing. The reflectivity vortex hole observed on 11 August 2011 was analyzed using both constant-elevation and three-dimensional radar imagery. Polarimetric data from WSR-88Ds in close proximity to four prominent tornadoes from May and June 2013 revealed at least brief reflectivity vortex holes with each of those cases and suggested that recognition of vortex holes by meteorologists may supplement information from polarimetric tornadic debris signatures.

Accepted: 20 February 2014

Where are the indigenous scientific leaders? Examining the participation of Native American/Alaska Natives in weather and water academic programs and the federal workforce
Bulletin of the American Meteorological Society (BAMS)

S. V. Cooten (NWS/Lower Mississippi River Forecast Center)

- Data sets documenting demographics and salaries of the federal science and engineering workforce show Native American (American Indian)/Alaska Natives (AI/AN) are the smallest workforce segment among minorities and receive the lowest average salaries for engineers and physical scientists.
- The recruitment pool for the federal AI/AN science and engineering workforce suffers from the lack of AI/AN enrolling and matriculating through engineering and earth, atmospheric and ocean science academic degree programs.
- Native Americans have ownership rights to natural resources in their homelands and areas they were relocated to. The absence of AI/AN in discussions that ultimately





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determine the sustainable management of natural resources including water, oil, natural gas, forests, minerals, and fisheries continues to cost the U.S. billions of dollars in litigation costs and settlements.

Native American (American Indian)/Alaska Natives (AI/AN) are significantly underrepresented in the U.S. federal science and engineering labor force. This underrepresentation extends into the leadership ranks of federal agencies responsible for designing, implementing, and maintaining resource monitoring and enforcement programs on tribal lands. Data sets documenting demographics and salaries of the federal science and engineering workforce show AI/AN are the smallest workforce segment among minorities and receive the lowest average salaries for engineers and physical scientists. Academic statistics show AI/AN students earn significantly fewer engineering and earth, atmospheric and ocean science bachelor's degrees than other ethnic groups and rarely earn advanced degrees in these disciplines. Additional aspects in federal and academic data sets offer clues on a spectrum of causative factors affecting the AI/AN recruitment pool for federal S&E jobs and the rarity of AI/AN ascending to leadership positions with federal scientific organizations.

Expected Publication Date: Summer 2014

Impact of hypoxia on habitat quality of pelagic planktivorous fishes in the Northern Gulf of Mexico

Marine Ecology Progress Series

H. Zhang, **D. M. Mason**, **C. A. Stow** (OAR/GLERL), A. T. Adamack, S. B. Brandt, **X. Zhang** (NMFS/SEFSC), D. G. Kimmel, M. R. Roman, W. C. Boicourt, and S. A. Ludsin

- Evaluates impact of hypoxia on habitat quality of pelagic prey fishes using a spatially-explicit, bioenergetics-based growth rate potential (GRP) model to develop indices. Focus on the pelagic bay anchovy (*Anchoa mitchilli*) and Gulf menhaden (*Brevoortia patronus*).
- Findings show that hypoxic areas were always low quality habitat. However, with respect to the entire water column, hypoxia had only a minor impact on overall habitat quality, with habitat quality being driven primarily by prey availability followed by water temperature.





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- Study concludes that current hypoxia at the northern Gulf of Mexico has minor negative impacts on overall habitat quality of two pelagic planktivorous fish species (bay anchovy and Gulf menhaden). It underlines the importance of studying the vertical extent of hypoxia on the water column.

To evaluate the impact of hypoxia (<2 mg O₂ l⁻¹) on habitat quality of pelagic prey fishes in the northern Gulf of Mexico, we used a spatially-explicit, bioenergetics-based growth rate potential (GRP) model to develop indices of habitat quality. Our focus was on the pelagic bay anchovy (*Anchoa mitchilli*) and Gulf menhaden (*Brevoortia patronus*). Positive GRP was considered high quality habitat (HQH) and negative GRP was considered low quality habitat (LQH). Models used water temperature, dissolved oxygen (DO), zooplankton biomass, and phytoplankton concentration collected during the peak periods of hypoxia in 2003, 2004, and 2006 to estimate fish GRP. Results showed that hypoxic areas were always LQH. However, with respect to the entire water column, hypoxia had only a minor impact on overall habitat quality, with habitat quality being driven primarily by prey availability followed by water temperature. These results are in contrast to other ecosystems, such as the Chesapeake Bay, where hypoxia affects a larger fraction of the water column than the Gulf of Mexico and has a significant impact on overall habitat quality. Differences in the effect of hypoxia on habitat quality between these two ecosystems suggest that the vertical extent of hypoxia relative to water column depth (i.e., hypoxic volume) is a fundamental consideration when evaluating the impacts of hypoxia on pelagic fish production.

Expected Publication Date: Summer 2014

